

# 1

## Volcanoes ...and Your Community

### Getting Started



In 1883, on the island of Krakatoa in the East Indies, one of the most violent eruptions of recorded time took place. Half of the island was blown away by a volcanic eruption. Over a cubic mile of rock was hurled into the air. The sound of the explosion was heard in Australia, over 2000 miles away.

- Can a volcano that erupts on the other side of the world affect your community?

What do you think? Look at the Earth systems at the front of this book. In your notebook, draw a picture to show one way that a volcanic eruption changes an Earth system. Then, think about how that change might cause a change in another Earth system. Add this to your drawing. Continue until you have connected the volcanic eruption to your community. Be prepared to discuss your pictures with your small group and the class.

### Scenario

“The clouds became thicker, and it was increasingly difficult to see as we struggled up the narrow, steep path toward the summit. The ground was hot under our feet, but the moisture from the clouds kept us cold and damp, and made the ash stick to our hair and eyelashes. We began to see larger volcanic rocks, some as large as two feet across. Suddenly we came across a large fissure, about one foot wide and 60 feet long. As I leaned over it, a hot blast of sulfur-smelling air scorched my nostrils. Then, like a warning growl from a watchdog, came a rumble from deep within. This was the moment we had been anticipating with dread...”

Many motion pictures are based on exciting geologic events.

Can you use your knowledge of volcanoes to make a thrilling, yet informative and scientifically correct movie?

## Chapter Challenge

Your challenge is to write a screenplay or story, set in your community, that would help audiences understand volcanoes. You need to teach them about volcanic hazards. You also need to help them see volcanoes as part of the Earth system, and to realize that volcanoes affect all communities in some way. Can you use Earth science to create an exciting story and help others understand the hazards and the benefits of volcanoes?

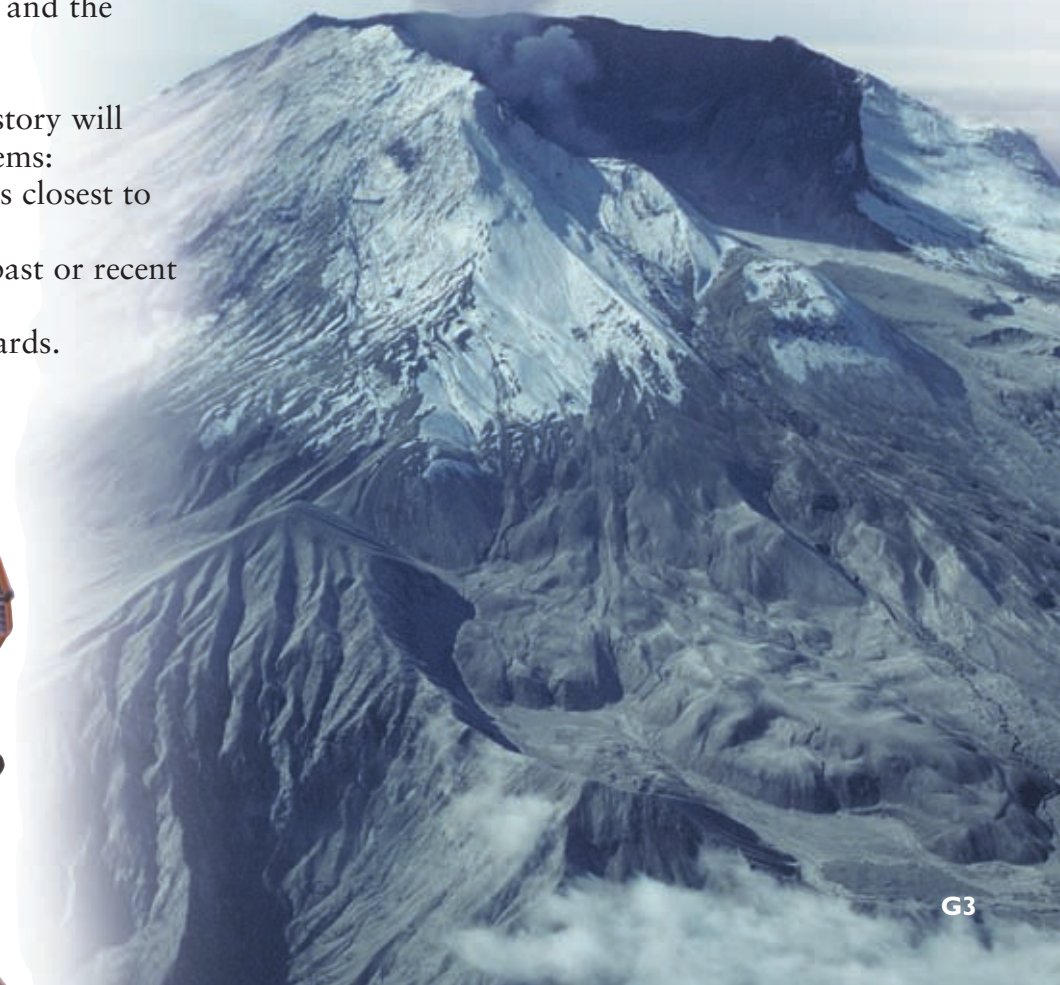
Think about how your story will address the following items:

- Locations of volcanoes closest to your community.
- Evidence that shows past or recent volcanic activity.
- Types of volcanic hazards.

- How volcanoes change the atmosphere, hydrosphere, and other Earth systems.

## Assessment Criteria

Think about what you have been asked to do. Scan ahead through the chapter activities to see how they might help you to meet the challenge. Work with your classmates and your teachers to define the criteria for assessing your work. Record all this information. Make sure that you understand the criteria as well as you can before you begin. Your teacher may provide you with a sample rubric to help you get started.







## Activity 1

## Where are the Volcanoes?



### Goals

In this activity you will:

- Find the latitude and longitude of volcanoes nearest your community when given a map of historically active volcanoes.
- Search for and describe patterns in the global distribution of volcanoes.
- Make inferences about possible locations of future volcanic activity.
- Understand that most volcanism occurs beneath the ocean.
- Understand that map projections distort regions near the poles and eliminate some data.

### Think about It

Volcanoes are one of nature's most feared, yet spectacular activities.

- Can volcanoes form anywhere on Earth? Why or why not?

What do you think? Record your ideas about this question in your *EarthComm* notebook. Be prepared to discuss your responses with your small group and the class.



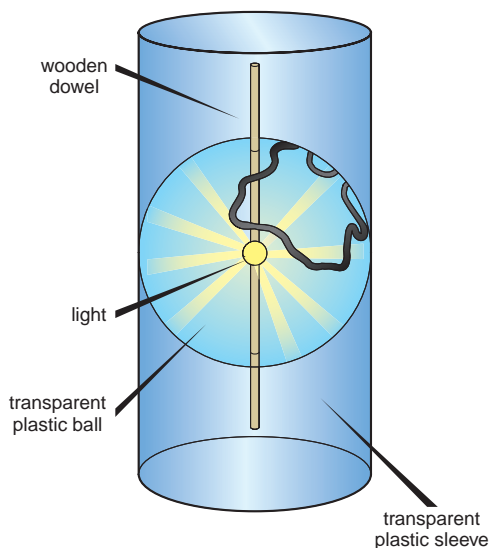
## Investigate

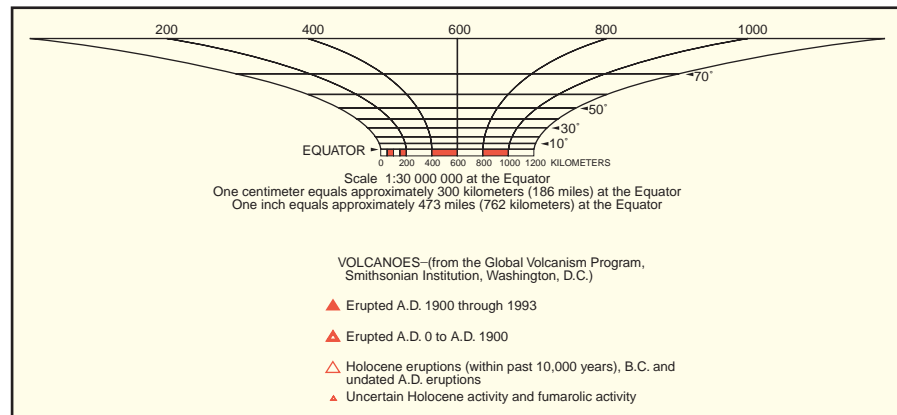
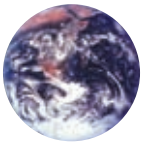
1. “Thought experiments” are experiments that scientists dream up and then run in their imagination, rather than in a real laboratory. They are a useful way to develop new ideas and insights into scientific problems. Here’s a thought experiment for you to do, to help you understand the Mercator map projection. It wouldn’t even be too difficult to do this in real life, if you could obtain the right materials.

Visualize a large, see-through plastic ball. Poke holes on opposite sides, and stick a wooden dowel through to make the North Pole and the South Pole. Install a bright light directly at the center of the ball, somehow. With a felt-tipped pen, draw a fake continent on the ball. Make the continent extend from near the Equator to near the North Pole. Now wrap a clear sheet of stiff plastic around the globe, to make a tight-fitting cylinder that’s parallel to the Earth’s axis. See the figure on the right for how to arrange this. Turn the light on, and observe how the border of your continent projects onto the plastic cylinder. Trace that image on the cylinder with the felt-tipped pen. Unwrap the cylinder from the globe, and lay it flat on the table. You now have a map with what’s called a Mercator projection of your continent!

- a) Describe how the image of your continent is changed in shape (distorted) when it is projected onto the cylinder.

- b) If you drew a short east–west line with a certain length near the southern end of your continent, and another east–west line with the same length near the northern end of your continent, how would the lengths of the lines compare when they are projected onto the cylinder map?
- c) If you drew a short north–south line with a certain length near the southern end of your continent, and another north–south line with the same length near the northern end of your continent, how would the lengths of the lines compare when they are projected onto the cylinder map?
- d) How would the image of a continent that is centered on the North Pole project onto the cylinder map?
- e) Which part of your map shows the least distortion?





2. Obtain the USGS map called *This Dynamic Planet*. Look at the map key, also shown above, to learn the meaning of the various symbols and how to use the map scale.
  - a) What do each of the four kinds of triangles represent?
  - b) What do the solid red lines represent?
  - c) Describe how the scale of the map changes with latitude.
  - d) Does the map cover the entire Earth? Why or why not?
3. For each time interval of volcanic activity shown on the map, find the latitude and longitude of three volcanoes closest to your community.
  - a) Make a data table to record your results. When complete, the data table should list 12 volcanoes.
  - b) Compare your data with that of other groups in your class. Did your class agree on the locations of the nearest historically active volcanoes? How did you resolve any differences?
4. Obtain a copy of a world map. Use this map to summarize any patterns in the global distribution of volcanoes.
  - a) When volcanoes follow a linear pattern, draw a thick line on the world map. Use the string of volcanoes within the Aleutian Islands and southern Alaska as an example.
  - b) For the red lines that appear on the USGS map, draw thin lines on your copy of the map. See the examples in the Pacific Ocean near Oregon and Washington.
  - c) Where volcanoes are less concentrated, outline (circle) the area that they cover. Try to be as accurate as possible. See the group of volcanoes in the Cascades as an example.
5. When your map is complete, answer the following questions in your notebook:
  - a) Are most volcanoes found in random places or do they show a trend or pattern? Explain.

- b) Does the USGS map show volcanoes that have not erupted during the last 10,000 years?
- c) Does the USGS map show eruptions after 1993, or new volcanoes?
- d) Does the USGS map show any volcanoes associated with the red lines in the ocean basins?
- e) What information does the map give about the size or hazard of the volcanoes?
- f) Suppose that tomorrow a volcano forms somewhere in the United States. Could it form in or near your state? Support your answer with evidence from this activity.
- g) What are some limitations of the evidence you used?



## Reflecting on the Activity and the Challenge

By looking at a world map of recent volcanic activity you found patterns in the data. This helped you to make inferences about the possible location of the next volcanic eruption in the United States. The data you looked

at are incomplete. This may limit the conclusions you can draw. However, you now have some knowledge that will help you decide where in the U.S. you might “stage” a volcanic eruption.

### Digging Deeper

#### THE GLOBAL DISTRIBUTION OF VOLCANOES

##### Volcanoes beneath the Sea

The USGS map *This Dynamic Planet* shows historical volcanic activity throughout the world. It tells a story about how our dynamic planet releases its internal storehouse of energy. No single source of data tells the whole story, but a map is a great place to begin.

On average, about 60 of Earth’s 550 historically active volcanoes erupt each year. Geologists have long known that volcanoes are abundant along the edges of certain continents. The presence of volcanic rocks on the floors of all ocean basins indicates that volcanoes are far more abundant under water than on land.







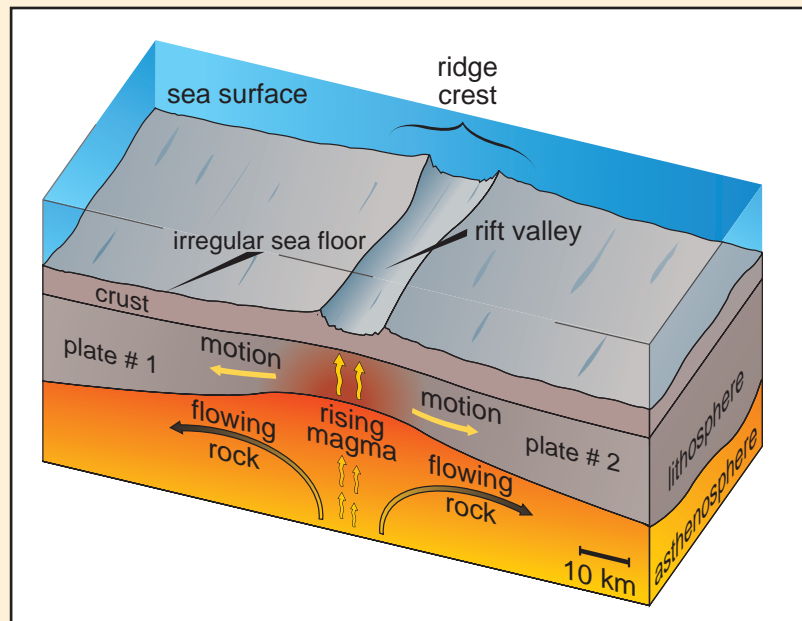
### Geo Words

**mid-ocean ridge:** a continuous mountain range extending through the North and South Atlantic Oceans, the Indian Ocean, and the South Pacific Ocean.

**rift valley:** the deep central cleft in the crest of the mid-oceanic ridge.

**magma:** naturally occurring molten rock material generated within the Earth

All of the Earth's ocean basins have a continuous mountain range, called a **mid-ocean ridge** extending through them. These ridges, over 80,000 km long in total, are broad rises in the ocean floor. They are usually in water depths of 1000 to 2000 m. *Figure 1* shows a vertical cross section through a mid-ocean ridge. At the crest of the ridge there is a steep-sided **rift valley**. **Magma** (molten rock) from deep in the Earth rises up into the rift valley to form submarine volcanoes. These volcanoes have even been observed by scientists in deep-diving submersibles. All of the floors of the oceans, beneath a thin layer of sediments, consist of volcanic rock, so we know that volcanoes form all along the mid-ocean ridges, at different times at different places. At a few places along the mid-ocean ridges, as in Iceland, volcanic activity is especially strong, and volcanoes build up high enough to form islands.



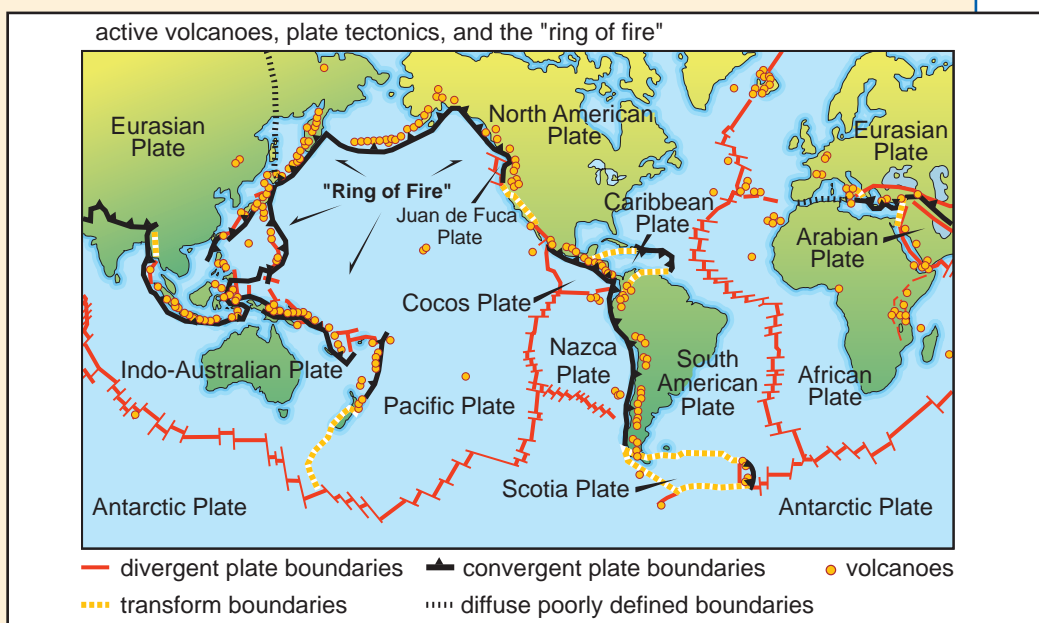
**Figure 1** Cross section through a mid-ocean ridge.

### Volcanoes on Land

Volcanoes that erupt on land are much more dangerous than volcanoes beneath the ocean. Eruptions along the western edge of the United States have formed the Cascades volcanic mountain range. They also form island chains, like the Aleutians in Alaska. Volcanoes like these are common in a narrow belt all around the Pacific Ocean. Geologists call this the "Ring of Fire." A famous example of an eruption along the Ring of Fire was the dramatic eruption of Mt. St. Helens in Washington in 1980.

## Ring of Fire

Around the edges of the Pacific Ocean, the plates of the Pacific Ocean slide down beneath the continents. Look at *Figure 2* to see an example. The Nazca Plate, moving eastward from the East Pacific Ridge, slides down beneath the west coast of South America. The plate is heated as it sinks into the much hotter rocks of the deep Earth. The heat causes fluids, especially water, to leave the plate and rise into overlying hot rocks. The added water lowers the melting point of the solid rock. If enough water is added the rock melts and magma is formed. The magma rises upward, because it is less dense than the rocks. It feeds volcanoes on the overlying plate. Nearly four-fifths of volcanoes on land form where one plate slides beneath another plate.



**Figure 2** The plates of the Earth, and the "Ring of Fire" around the Pacific. The circles show active volcanoes.

## Volcanoes Formed by Rifting on the Continents

Volcanoes in the East African rift valley form where two parts of the African continent are moving apart from each other. The process is very similar to what happens at mid-ocean ridges. The continental plate is stretched and broken. One of the breaks becomes the main one, and opens up to form the rift valley, as shown in *Figure 3*.







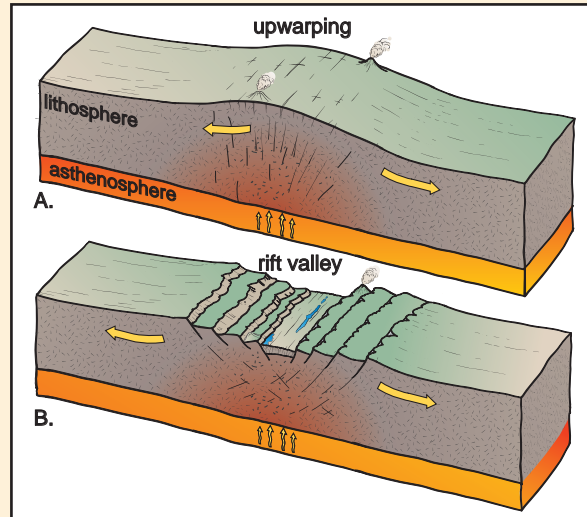
### Geo Words

**lava:** molten rock that issues from a volcano or fissure.

**hot spot:** a fixed source of abundant rising magma that forms a volcanic center that has persisted for tens of millions of years.

**map projections:** the process of systematically transforming positions on the Earth's spherical surface to a flat map while maintaining spatial relationships.

**Mercator projection:** a map projection in which the Equator is represented by a straight line true to scale, the meridians by parallel straight lines perpendicular to the Equator and equally spaced according to their distance apart at the Equator, and the parallels by straight lines perpendicular to the meridians and the same length as the Equator. There is a great distortion of distances, areas, and shapes at the polar regions.



**Figure 3** Formation of a rift valley on a continent.

In the United States, continental rifting long ago formed the rocks that make up the tall cliffs on the western bank of the Hudson River. These rocks formed when magma intruded the crust during this rifting. The rocks are seen for more than 80 km along the bank of the Hudson River and can be up to 300 m thick! Other evidence of magma formed during this rifting is found in many states along the East Coast.



**Figure 4** Mount Kilimanjaro is a famous example of volcanism at a continental rift. Many other volcanoes in the East African rift valley have erupted in historic times.

### Volcanoes at Hot Spots

Volcanoes discussed so far occur near the edges of plates. However, a small percentage of volcanoes occur in the interior of a plate. The Hawaiian Islands, shown in *Figure 5*, are an example. Studies of volcanic rock show that

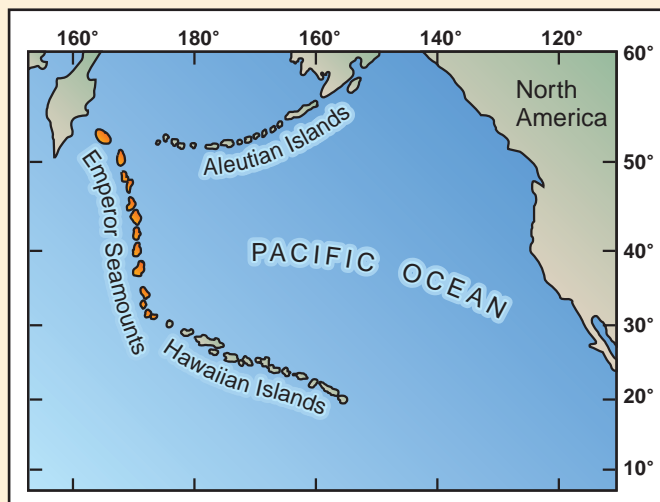
the islands get older to the northwest. Only the youngest island, the “big island” of Hawaii, has active volcanoes.

Here’s how geologists explain the pattern of the Hawaiian Islands. Deep beneath Hawaii, there is a fixed source of abundant rising magma, called a **hot spot**. As the

Pacific Plate moves to the northwest, away from the East Pacific Ridge, it passes over the fixed hot spot. Magma from the hot spot punches its way through the moving plate to form a chain of islands. The sharp bend in the chain was formed when the direction of movement of the plate changed abruptly at a certain time in the past. Far to the northwest the chain consists of **seamounts**.

### Map Projections

There is always a big problem in drawing a map of the world, because you have to try to show the curved surface of the Earth’s globe on a flat sheet of paper. Many different ways of doing this, called **map projections**, have been developed, but they all have some kind of distortion. The USGS map uses a **Mercator projection**. As you move away from the Equator, the map becomes more and more distorted. For example, it makes all lines of latitude look like they are equal in length. This makes it difficult to measure distances on the map. Another problem is that the USGS map stops at 70° north and south latitude, because of the Mercator projection. This keeps you from seeing all of the data. For example, the USGS map cuts off the mid-ocean ridge north of Iceland. The scale of the map also presents a problem. The larger the area covered by the map, the less detail the map can show. In this case, the triangular symbols that represent volcanoes often overlap in areas with many volcanoes. This makes them difficult to count.



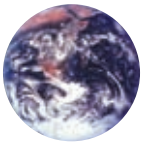
**Figure 5** The Hawaiian island chain and the Emperor seamount chain.

### Geo Words

**seamount:** a peaked or flat-topped underwater mountain rising from the ocean floor.

### Check Your Understanding

1. What evidence do geologists have that volcanoes occur on the ocean floor?
2. What is the Ring of Fire, and where is it located?
3. Where do most volcanoes on land form?
4. How are rift valleys formed?
5. What are hot spots? Provide an example of a hot spot on Earth.
6. Why does the horizontal scale of a Mercator projection increase with latitude?



## Understanding and Applying What You Have Learned

1. What difficulties did you have finding the latitude and longitude of volcanoes?
2. Where on Earth do most volcanoes occur? Explain your answer.
3. Are most volcanoes on land caused by the Earth's plates moving away from each other or moving toward each other? Explain your answer.
4. In your own words, describe the likely cause of historically active volcanoes in:
  - a) The continental United States.
  - b) The Aleutian Islands and southern Alaska.
  - c) The Hawaiian Islands.
5. Based on your results from this investigation, list the five states that you think are most likely to experience the next volcanic eruption. Explain each choice.
6. Of the average of 60 volcanoes that erupt in any given year, how many are likely to erupt along the Ring of Fire?
7. Why did the Mercator projection not show volcanoes near the Earth's poles?
8. Do most volcanoes on land occur in the Northern Hemisphere or the Southern Hemisphere? Explain why you think this is so.

## Preparing for the Chapter Challenge

Think about how you can help the audience understand why you chose the probable location of the volcanic eruption for your story. Explain the map that you made for this activity. Note the volcanic eruptions that are closest to your area. Explain where most volcanoes occur in the United States. You should also note where they have not happened recently.





## Inquiring Further

### 1. Eruptions near your community

Find out more about the historical eruptions at the volcanoes nearest your community. The Volcano World web site lists hundreds of historically active volcanoes. (Consult the AGI *EarthComm* web site for current addresses.) Your data table of latitudes and longitudes will help you to identify them.

### 2. Volcanoes and the water on Earth (the hydrosphere)

Research to find answers to the following questions, and any other questions which you have formed:

- How do volcanoes at mid-ocean ridges affect the temperature of seawater?
- How do volcanoes change the chemistry of seawater?
- How does seawater affect the composition of the volcanic rock that is formed at the mid-ocean ridge?
- Would volcanoes affect a small body of seawater, such as the Red Sea, the same way as a large ocean like the Atlantic?
- Can a change in the volume of volcanic rock formed at mid-ocean ridges change sea level?

